DOCUMENT RESUME

ED 086 747 TM 003 417

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TITLE The Series Test As A Measure of Learning Potential. Studies in Learning Potential, v3, n47.
INSTITUTION Research Inst. for Educational Problems, Cambridge, Mass.
PUB DATE 73
NOTE 71p.

EDRS PRICE MF-$0.65 HC-$3.29
DESCRIPTORS Aptitude Tests; *Elementary School Students; Evaluation Techniques; *Intelligence Differences; Intelligence Tests; *Serial Learning; *Social Differences; *Test Construction; Test Reliability; Training
IDENTIFIERS *Series Learning Potential Test

ABSTRACT

The purposes of the study to determine psychometric characteristics of the Series Learning Potential Test, the effects of Learning Potential training on Series scores, and the relationship of Series scores to IQ, race, social class, and reading achievement. The Series Test was administered to students in 79 classrooms in five Connecticut towns which differed in racial and socioeconomic composition. The test was shown to be highly reliable, and the two forms were found to be statistically equivalent. Difficulty levels of several items indicated a ceiling effect reflected in total scores. Training was found to be effective with second and third graders from lower class towns and first and second graders in middle class towns. Series scores were positively related to IQ and reading scores, and students who were white or middle class attained higher Series scores. For these reasons, as well as the ceiling effect, the Series test appears to be less useful than other tests as a measure of Learning Potential. (Author)

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STUDIES IN LEARNING POTENTIAL

THE SERIES TEST AS A MEASURE OF LEARNING POTENTIAL

TM 003 417

by

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Volume 3, Number 47

1973

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THE SERIES TEST AS A MEASURE OF LEARNING POTENTIAL

Abstract

The purposes of the study were to determine psychometric characteristics of the Series Learning Potential test, the effects of Learning Potential training on Series scores, and the relationship of Series scores to IQ, race, social class, and reading achievement. The Series Test was administered to students in 79 classrooms in five Connecticut towns which differed in racial and socioeconomic composition. The test was shown to be highly reliable, and the two forms were found to be statistically equivalent. Difficulty levels of several items indicated a ceiling effect reflected in total scores. Training was found to be effective with second and third graders from lower class towns and first and second graders in middle class towns. Series scores were positively related to IQ and reading scores, and students who were white or middle class attained higher Series scores. For these reasons, as well as the ceiling effect, the Series test appears to be less useful than other tests as a measure of Learning Potential.

THE SERIES TEST AS A MEASURE OF LEARNING POTENTIAL[1]

Louise Corman and Milton Budoff

Research Institute for Educational Problems

Budoff (1970) has described a learning potential (LP) procedure for assessing ability among low-IQ, low-SES children based on a process-oriented conceptualization of intelligence. The focus of the LP paradigm is on the child's trainability, i.e., his ability to improve performance on reasoning problems following a systematic learning experience. Reasoning is viewed as the critical ability. The reasoning tasks are administered in a "test-train-test" sequence. Training allows the low-SES child to understand how to solve the problems when the contents of the problems may be strange and the appropriate strategies are not readily apparent to him.

Training is hypothesized to be particularly critical for the child from a poor and/or nonwhite background, who may learn different cognitive strategies in different expressive formats than those presumed to be available by the tests. The training helps the child to narrow the cognitive gap between his previously learned problem-solving strategies and those implicit to the problems he must ordinarily solve on the middle-class-biased tests he encounters. The test-train-test paradigm also minimizes the artificiality of the test situation. The repeated contacts with the materials in a context of support and teaching allows the school-failing child to develop a sense that he can be competent. Without this competence boost, he tends not to perform at his best, implicitly expecting failure (Zigler, 1966). The essence of this assessment strategy, then, is to impose some control on the potentially negative effects on his test performance of prior life experiences.

The pretest reflects the subject's present level of functioning, and his existing ability to work with the problems. Posttraining scores reflect the child's ability under optimized conditions in which all subjects are familiar with the task and its demands, have had success in solving problems similar to those on the test, and have had the opportunity to learn and apply relevant strategies. Budoff and Corman (in press) have shown that EMRs' pretest scores on Kohs Block Designs correlate highly with Stanford-Binet and Wechsler scores and other indices of psychosocial vulnerability associated with socioeconomic status. Post-training scores were correlated only with performance scale scores.

To date, nonverbal reasoning tasks have been used since these are not dependent on language, which represents one major area of these children's difficulties. Three nonverbal tasks have been employed in assessment of LP: an altered version of the Kohs Block Designs (Budoff, 1969), Raven's Progressive Matrices (Budoff, 1970), and the Series Learning Potential Test (SLPT, Babad & Budoff, in press).

The SLPT, used in the present study, is a group test for the primary and elementary grades. Its major task is the completion of series of pictures or geometric forms, arranged in a pattern in which the figures change systematically. Each item presents a horizontal row of cells each of which contains a stimulus figure. One cell is left blank. The subjects must identify among the multiple choices on the right the picture which best completes the series. Four concepts may vary in a series: semantic content (meaningful or geometric figures), size (large/small), color (black/white), or orientation (up/down, or left/right). The concepts may vary symmetrically or asymmetrically and the blank space may be placed in any part of the series. The hardest items are those in which the blank space appears early in the series, and the concepts change asymmetrically.

Two 65-item forms of the test are used, with items corresponding in concepts but with different pictures in similar arrangements. None of the 17 coaching items is identical to any of the 130 test items. The test contains several types of items. Forty items (Picture Series) consist of meaningful pictures ranging from easy items (two concepts are arranged symmetrically and the blank space appears at the end of the series) to more difficult ones (asymmetric alternation of three concepts, blank space in initial position). Improvement in solving the meaningful picture series on the posttest indicates the child can solve nontrained instances of the trained items. Ten items (Geometric Series) with geometric figures discern whether S can transfer the strategies learned in training with meaningful pictures to dissimilar stimuli. Fifteen double-classification items, including five matrices in meaningful pictures (Picture Matrices) and ten in geometric symbols (Geometric Matrices) are presented in a matrix format, test for generalization of the learned strategies to problems that require the same reasoning process in a different arrangement. The strategies may also be mediated differently.

Specific purposes of this study were to determine (a) psychometric characteristics of the two Series forms, (b) differences in initial performance by grade level (grades 1 to 4), (c) effects of training, (d) the relationship of IQ,

race, and social class to performance on the Series Test, and (e) the relationship of reading and vocabulary scores to scores on the Series test.

Method

Subjects

The Series Test was given to first through fourth grade students in 79 classrooms in Darien, Hartford, Ledyard, Stamford, Wilton, and Westport (one parochial school only), Connecticut. The majority of students in Hartford and Stamford were black (98.7% and 76.2%, respectively) and from low socioeconomic backgrounds. Students in the other four towns were predominantly white and middle class (Table 8). The total sample was evenly divided among males and females and ranged in age from approximately six to ten years.

Procedure

Four different assessment procedures were used. In the majority of classrooms (50) all students received Form A as pretest, were trained, and took Form B as posttest. Half the students in four classrooms in Ledyard got Form A as pretest and Form B as posttest, with no training between the two tests; the other half got Form B, then Form A, with no training. One classroom in Stamford was assigned Form B as pretest and Form A as posttest, with training given between the two tests. The remaining classrooms (24) were used as a "training study" sample so that the effects of training could be assessed. Each student in the training study was randomly assigned to a trained or non-trained group and to Form A or Form B. These students received the same test form for pre- and posttesting. The training study sample consisted of five first grade, seven second grade, nine third grade, and three fourth grade classrooms from five of the Connecticut towns (Westport was not represented). Posttesting took place within one week after pretesting.

Five strategies were taught and practiced during training:

1. The students learned to identify each concept that changes.
2. They learned to "sing the tune" for each concept, one at a time as an organizational or chunking aid to identify the pattern of each concept.
3. To reduce the memory load in a multi-concept item, the student crossed out the wrong choices for each concept.
4. The child learned to reverse the direction in which the tune is sung when the location of the blank space calls for such reversal, e.g., blank at the beginning of a series.

5. The child learned to identify the starting point of a concept when the series starts in the middle of the pattern.

All 17 problems were successfully solved by the end of the 30- to 45-minute training session. Appendix A has the instructions for administration and training on the SLPT.

Information pertaining to race, social class, scores on a group IQ test, and scores on the Gates-MacGinitie Reading Test was obtained on all students in the 79 classrooms for whom this data was available.

Results

Test Characteristics

To assess the psychometric characteristics of the two test forms, test-retest reliabilities were calculated, and correlations between scores on the two forms were obtained to provide a measure of form equivalence. In addition, item analyses and factor analyses were calculated on each form before and after training.

The sample for the test-retest reliabilities consisted of 120 nontrained training study subjects for Form A and 93 similarly selected subjects for Form B. Form equivalence was obtained for all subtests and the total test by correlating the pre- and posttest scores of the 106 students in the four Ledyard classrooms who received no training.

The sample for the item and factor analyses before training consisted of all students who received as pretest the form being analyzed, as well as some nontrained students who received that form on the posttest but not on the pretest. For Form A the sample was 1416 students, including the 50 classrooms who got AB and training, the students in the four Ledyard classrooms who got BA or AB and no training, and half of the training study sample who got Form A. The sample for Form B was much smaller, since the 50 classrooms who got form A, training, and Form B had to be excluded. This sample consisted of 327 students, including students in the four Ledyard classrooms who got Form B, then Form A, or Forms A then B with no training, half of the training study sample who got Form B, and the Stamford class who got Form B then A and training.

The item and factor analyses after training were calculated from posttest responses of 177 students for Form A and 1115 students for Form B. The sample for Form A comprised trained students in the training study group who got Form A

and the Stamford class who got Form B, then A and training. For Form B, the sample included students in the 50 classrooms who got Form A, then B and training and trained students in the training study group who took Form B.

In order to perform item and factor analyses, all item responses were dichotomized as either correct or incorrect. KR20 reliability coefficients were determined with the samples employed in the pretest item analysis. KR20, test-retest, and alternate form reliability coefficients are presented in Table 1. All three types of reliability were high for the total test. Test-retest and alternate form coefficients for the separate subtests were lower but were in the moderate range.

Insert Table 1 about here

Table 2 shows the difficulty levels of Series items on each form before and after training. The number of options varied on different items; therefore, in order to compare difficulties across items the difficulty levels presented in this table were corrected by subtracting the chance score from the percentage obtained when each item had been considered either right or wrong. It can be seen that the majority of items were either very easy or very difficult; few items had difficulties between .45 and .55. Although the percentage of students who passed many items rose after training, training had no effect on the most difficult items, most of which were on the Picture Series Subtest.

Insert Table 2 about here

In the factor analyses on the 65 items, four factors were extracted, in accordance with the theoretical structure of four subtests. Loadings of items on the first principal component before and after training are presented in Table 2 beside the item difficulties. It was expected that items which were originally difficult would have higher loadings on the first principal component after training, because training might have reduced difficulties of these items and more closely aligned them with what the test measures. It was also thought that loadings of initially easy items on the first principal component would be reduced after training. Neither of these expectations was borne out with any consistency since training had little effect on the very easy or very hard items.

Both the difficulty level and loading of any given item were comparable for the two forms, reflecting the parallel construction of the tests.

TABLE 1

KR20, Test-Retest and Alternate Form Reliability Coefficients for the Series Test

	Form A		Form B		Alternate-form r	
		N		N		N
KR20	.95	1416	.95	327		
Test-retest						
Total test	.87	120	.90	93	.84	106
Picture series subtest	.83	120	.82	93	.75	106
Geometric series subtest	.79	120	.83	93	.71	106
Picture matrix subtest	.69	120	.78	93	.67	106
Geometric matrix subtest	.70	120	.80	93	.76	106

Table 2

Corrected Difficulty Levels and Loadings on First Principal Component of All Series Items

Item[a]	Difficulties[b]				Loadings			
	Before training		After training		Before training		After training	
	Form A	Form B	Form A	Form B	Form A	Form B	Form A	Form B
1	.73	.74	.73	.74	-.19	-.13	-.17	-.22
2	.72	.71	.67	.73	-.11	-.26	-.37	-.25
3	.39	.56	.57	.66	-.63	-.51	-.65	-.54
4	.50	.57	.65	.68	-.51	-.53	-.51	-.57
5	.49	.55	.57	.67	-.62	-.57	-.69	-.54
6	.44	.45	.57	.65	-.73	-.66	-.57	-.56
7	.58	.61	.61	.66	-.48	-.38	-.35	-.42
8	.43	.50	.59	.64	-.73	-.70	-.58	-.65
9	.41	.47	.57	.65	-.60	-.50	-.55	-.48
10	.48	.49	.54	.58	-.54	-.59	-.57	-.58
11	.44	.44	.46	.53	-.64	-.59	-.67	-.59
12	.36	.37	.46	.52	-.59	-.53	-.57	-.55
13	.38	.41	.48	.57	-.66	-.68	-.56	-.62
14	.19	.19	.22	.34	-.37	-.42	-.31	-.33
15	.29	.32	.44	.53	-.62	-.64	-.65	-.57
16	.39	.47	.46	.58	-.44	-.55	-.52	-.41
17	.23	.30	.32	.46	-.56	-.54	-.50	-.53
18	.44	.57	.51	.70	-.56	-.33	- 52	-.38
19	.32	.40	.38	.56	-.65	-.70	-.66	-.65
20	.56	.61	.60	.66	-.43	-.42	-.38	-.44

Table 2 (continued)

Item[a]	Difficulties[b]				Loadings			
	Before training		After training		Before training		After training	
	Form A	Form B	Form A	Form B	Form A	Form B	Form A	Form B
21	.46	.47	.60	.60	-.57	-.57	-.51	-.55
22	.32	.34	.35	.46	-.56	-.53	-.54	-.51
23	.38	.46	.46	.60	-.62	-.69	-.66	-.65
24	.53	.51	.52	.62	-.55	-.59	-.65	-.54
25	.32	.35	.34	.42	-.46	-.55	-.54	-.51
26	.38	.42	.47	.52	-.49	-.44	-.56	-.45
27	.09	.10	.19	.18	-.30	-.30	-.28	-.26
28	-.02	-.04	.07	.08	-.13	-.15	.07	-.02
29	.04	.18	.01	.30	-.26	-.34	-.40	-.44
30	.03	.03	.12	.10	-.15	-.09	-.06	-.01
31	-.08	.03	-.05	.05	-.14	-.19	-.07	-.22
32	.00	-.01	.04	.06	.06	-.02	-.13	-.00
33	.31	.32	.33	.45	-.48	-.52	-.34	-.45
34	.10	.13	.16	.15	-.18	-.11	-.13	-.16
35	.03	.11	.08	.19	-.18	-.31	-.35	-.34
36	.40	.39	.50	.56	-.68	-.73	-.61	-.61
37	.01	-.02	.07	-.00	.03	.03	.03	.02
38	.11	.15	.10	.22	-.27	-.40	-.30	-.35
39	.10	.11	.18	.17	-.26	-.33	-.28	-.25
40	.05	.10	.11	.17	-.13	-.08	-.14	-.14
41	.45	.52	.50	.59	-.56	-.50	-.60	-.55
42	.36	.40	.40	.51	-.71	-.67	-.58	-.67

Table 2 (continued)

Item[a]	Difficulties[b]				Loadings			
	Before training		After training		Before training		After training	
	Form A	Form B	Form A	Form B	Form A	Form B	Form A	Form B
43	.21	.16	.19	.14	-.58	-.53	-.52	-.59
44	.26	.33	.29	.42	-.57	-.58	-.69	-.66
45	.18	.18	.19	.19	-.42	-.24	-.27	-.25
46	.05	.11	.11	.16	-.09	-.24	-.03	-.13
47	.46	.44	.48	.57	-.59	-.55	-.51	-.53
48	.18	.13	.16	.20	-.52	-.54	-.59	-.56
49	.35	.33	.37	.47	-.64	-.67	-.63	-.62
50	.07	.09	.08	.20	-.45	-.49	-.48	-.49
51	.59	.58	.61	.66	-.42	-.43	-.45	-.45
52	.39	.43	.47	.56	-.53	-.62	-.50	-.64
53	.20	.26	.20	.41	-.58	-.67	-.50	-.58
54	.24	.26	.30	.40	-.61	-.66	-.62	-.68
55	.31	.34	.32	.44	-.59	-.66	-.69	-.58
56	.54	.55	.55	.62	-.45	-.53	-.55	-.51
57	.46	.45	.47	.57	-.63	-.66	-.73	-.60
58	.23	.26	.20	.36	-.63	-.67	-.69	-.66
59	.06	.13	.08	.21	-.25	-.37	-.36	-.42
60	-.04	.06	-.04	.04	-.13	-.20	-.03	-.28
61	.21	.19	.22	.26	-.60	-.59	-.56	-.58
62	.30	.29	.34	.40	-.69	-.78	-.66	-.72

Table 2 (continued)

Item[a]	Difficulties[b]				Loadings			
	Before training		After training		Before training		After training	
	Form A	Form B	Form A	Form B	Form A	Form B	Form A	Form B
63	-.01	.02	-.06	.02	-.38	-.39	-.37	-.35
64	.14	.17	.16	.23	-.55	-.57	-.54	-.53
65	.20	.22	.24	.31	-.53	-.57	-.61	-.49
N	1416	327	177	1115	1416	327	177	1115

[a]Items 1 to 40 are Picture Series, 41 to 50 are Geometric Series, 51 to 55 are Picture Matrix, and 56 to 65 and Geometric Matrix.

[b]Chance scores have been subtracted from obtained difficulty levels, resulting in negative difficulty levels in some instances.

Table 3 shows the percent of variance accounted for by the factors on both forms before and after training. Inspection of factor loadings of the 65 items after a varimax rotation indicated that of the four subtests, only the Picture Series clearly emerged as a factor. This finding held for both forms before and after training. The total variance accounted for by the factors was about one-third, and this percent did not change with training.

Insert Table 3 about here

In the pretest analysis of Form A, of the 27 items whose highest loadings (> .20) were on Factor 1, 25 were contained in the Picture Series subtest. Of the 23 items with high loadings on Factor 2 all but six were Geometric Matrix, Picture Matrix, and Geometric Series questions. The eight items with high loadings on Factor 3 were those which had very high difficulty levels (between .62 and .98, uncorrected by chance score), as revealed by the item analysis. The six items with high loadings on Factor 4 all had extremely low discrimination indices (between -.03 and +.18), as shown by the item analysis.

The pretest factor structure of Form B showed a slightly different pattern. Factor 1 comprised 28 items with loadings above .20. This factor most nearly resembled the Geometric factor of Form A, since all but one of the 15 items with loadings above .50 were from the Geometric Matrix, Geometric Series, and Picture Matrix Subtests. Unlike Form A, however, several Picture Series items had loadings between .20 and .50 on this factor. Factor 2 on Form B corresponded to Factor 3 on Form A and, with one exception, comprised items with difficulty levels between .61 and .99.

Factor 3 on Form B was a Picture Series factor, since 19 of the 21 items with loadings above .20 on Factor 3 were Picture Series questions. The Picture Series factor accounted for less variance in Form B than in Form A because part of the variance accounted for by Factor 1 in Form B was due to the high loadings of Picture Series items on that factor. Factor 4 on Form B was similar to Factor 4 on Form A but consisted of only two items (discrimination indices = .01 and .06).

The factor structure of both forms after training remained similar to that of Form B before training. Factor 1 of Form A consisted of 25 items, including 14 non-Picture Series and 11 Picture Series items. Factor 2 was made up of 20 items, all of which were easy Picture Series items

Table 3

Percent of Variance Accounted for by Four Factors before and after Training (Varimax Rotation)

	Before training			After training		
Form A	Name	% of common variance	% of total variance	Name	% of common variance	% of total variance
Factor 1	Picture series	76.11	24.88	Geometric and picture series	71.52	24.87
Factor 2	Geometric	10.38	3.39	Picture series	13.70	4.76
Factor 3	Easy	8.13	2.65	Easy	8.23	2.86
Factor 4	Low discriminator	5.38	1.75	Low discriminator	6.55	2.28
Total		100.00	32.67		100.00	34.77
N	1416			177		
Form B						
Factor 1	Geometric and picture series	76.69	25.72	Geometric and picture series	74.41	23.92
Factor 2	Easy	10.79	3.61	Picture series	12.65	4.07
Factor 3	Picture series	7.46	2.50	Easy	7.40	2.38
Factor 4	Low discriminator	5.06	1.69	Low discriminator	5.54	1.78
Total		100.00	33.52		100.00	32.15
N	327			1115		

(difficulty levels between .63 and .98). Factor 3 comprised 11 easy, non-Picture series items (difficulties between .62 and .86 on 10 of the items). Factor 4 had seven items, six of which had discriminations between -.01 and .19.

For Form B after training, Factor 1 consisted of 17 non-Picture Series and 12 Picture Series items. Factor 2 was made up of 23 items 22 of which were Picture Series items. As with Form A, these were easy items, with difficulties between .70 and .99. Factor 3 comprised five non-Picture Series items with difficulties between .74 and .91, and Factor 4 had eight items, six of which had discriminations between .06 and .19.

Table 4 permits closer examination of the relationship between the difficulties and factor loadings of Picture Series items. It can be seen that the easiest items on this subtest usually had higher loadings on the pure Picture Series Factor than on the Geometric and Picture Series Factor, although this finding was less consistent on the Form B pretest. The most difficult Picture Series items most often had high loadings on the Geometric and Picture Series Factor. The pure Picture Series Factor contained, for the most part, easier picture series items. The table also indicates that Picture Series items whose initial difficulty was in the moderate range were more susceptible to change with training than items which were originally very hard or very easy.

Insert Table 4 about here

Initial Differences by Grade and Town

Means and standard deviations were obtained by grade and town on both forms with the same sample which had been used for the item and factor analyses before training. Two one-way analyses of variance were computed for each form to determine differences in initial performance by grade and town.

Table 5 indicates that mean scores on the total Series Test were higher for students in Ledyard and Wilton than in Hartford and Stamford on both Series forms. This difference corresponded to the social class difference among these towns revealed by descriptive statistics. Mean total test scores by grade showed an upward linear trend. Differences by town and grade were significant at the .001 level in all analyses of variance.

Insert Table 5 about here

TABLE 4

Corrected Difficulty Levels of Picture Series Items with Loadings .20 on Picture Series (PS) Factors and Geometric and Picture Series (G) Factors

	Form A					Form B				
	Before training		After training			Before training		After training		
Item	Factor	Difficulty	Factor	Difficulty	Change in difficulty	Factor	Difficulty	Factor	Difficulty	Change in difficulty
1		.73	PS	.73	.00		.74	PS	.74	.00
2		.72	PS	.69	-.03		.71	PS	.73	.02
3	PS, G	.39	PS	.57	.18	PS, G	.56	PS	.66	.10
4	PS	.50	PS	.65	.15	PS, G	.57	PS	.68	.11
5	PS	.49	PS	.57	.08	PS, G	.55	PS	.67	.12
6	PS	.44	PS, G	.57	.13	PS, G	.45	PS	.65	.20
7	PS	.58	PS	.61	.03		.61	PS	.66	.05
8	PS	.43	PS, G	.59	.16	PS, G	.50	PS, G	.64	.14
9	PS, G	.41	PS, G	.57	.16	PS, G	.47	PS	.65	.18
10	PS, G	.48	PS, G	.54	.06	PS, G	.49	PS, G	.58	.09
11	PS, G	.44	PS, G	.46	.02	PS, G	.44	PS, G	.53	.09
12	PS, G	.36	PS, G	.46	.10	PS, G	.37	PS, G	.52	.15
13	PS, G	.38	PS, G	.48	.10	PS, G	.41	PS, G	.57	.16
14	PS	.19	G, PS	.22	.03	PS, G	.19	G, PS	.34	.15
15	PS, G	.29	PS, G	.44	.15	G, PS	.32	PS, G	.53	.21
16		.39	PS, G	.46	.07		.47	G, PS	.58	.11
17	G, PS	.23	G, PS	.32	.09	G, PS	.30	G, PS	.46	.16
18	PS, G	.44	PS, G	.51	.07	PS	.57	PS	.70	.13
19	PS, G	.32	G, PS	.38	.06	PS, G	.40	PS, G	.56	.16
20	PS	.56	PS	.60	.04		.61	PS	.66	.05
21	PS, G	.46	PS, G	.60	.14		.47	PS, G	.60	.13
22	PS, G	.32	G, PS	.35	.03	G, PS	.34	G, PS	.46	.12
23	PS, G	.38	PS, G	.46	.08	G, PS	.46	PS, G	.60	.14
24	PS	.53	PS	.52	-.01	PS, G	.51	PS, G	.62	.11
25	PS, G	.32	G, PS	.34	.02	G	.35	G, PS	.42	.07
26	G, PS	.38		.47	.09	G	.42	G, PS	.52	.10
27	PS	.09	G	.19	.10	G	.10	G	.18	.08
28						PS	-.04		.08	.12
29	G	.04	G	.01	-.03	G	.18	G, PS	.30	.12
30						PS	.03		.10	.07

TABLE 4 (continued)

	Form A					Form B				
	Before training		After training			Before training		After training		
Item	Factor	Difficulty	Factor	Difficulty	Change in difficulty	Factor	Difficulty	Factor	Difficulty	Change in difficulty
31		-.08	G	-.05	.03	PS	.03		.05	.02
32										
33	PS, G	.31		.33	.02	PS, G	.32	PS, G	.45	.13
34	PS	.10	G	.16	.06		.13	G	.15	.02
35	G	.03	G	.08	.05	G	.11	G	.19	.08
36	G, PS	.40		.50	.10	G, PS	.39	PS, G	.56	.17
37										
38	PS, G	.11	G	.10	-.01	G	.15	G	.22	.07
39	G	.10		.18	.08		.11	G	.17	.06
40						PS	.10		.17	.07

Note.--Loadings were obtained through varimax rotation of four factors: Picture Series (PS), Geometric and Picture Series (G), Easy, and Low Discriminator. PS and/or G factors are listed in the "Factor" column for items with highest loadings on those factors. The factor with the higher loadings is listed first. Items with high loadings on Easy or Low Discriminator factors and lower loadings on PS and/or G factors are left blank.

Table 5

Differences by Town and Grade on Total Series Pretest Scores

	Form A			Form B		
	Mean	SD	N	Mean	SD	N
Westport	34.30	15.16	100	---	---	0
Darien	34.36	13.65	310	---	---	0
Hartford	26.22	11.12	140	28.46	12.48	93
Ledyard	39.26	12.55	326	43.33	10.46	134
Wilton	39.41	13.90	170	46.17	8.60	24
Stamford	26.36	12.46	371	25.83	12.69	97
F	38.35*			60.09*		
df	5,1411			3,344		
Grade 1	23.44	11.39	309	22.19	12.17	74
Grade 2	31.79	13.82	427	35.03	13.38	101
Grade 3	36.98	13.31	430	39.21	12.64	102
Grade 4	41.06	11.43	251	40.66	11.58	71
F	119.42*			37.85*		
df	3,1413			3,344		

*p <.001

Effects of Training

The training study analysis was a four-way repeated measures design on the 471 subjects in the training study sample. Grade, Training Group, and Test Form were the between subjects factors; Test Session (pre and post) was the within subjects factor.

Means of trained and nontrained subjects on the pre- and posttest across Forms A and B are presented in Table 6. Trained subjects improved more than nontrained subjects in all grade levels; fourth graders, however, appeared to gain the least from training. These findings were further explained by the analysis of variance results presented in Table 7. It is noteworthy that there was no significant difference by Test Form. Grade and Test Session were significant main effects, as was expected from the cell means. The significant Group X Test Session interaction indicated that the trained group had a greater increase in mean score from pre- to posttest than did the nontrained group. Inspection of the Grade X Test Session interaction revealed a downward progression in mean score increase from the first to the fourth grade without regard to training group: from the pre- to posttest, mean scores of first graders rose six points, second graders rose five points, third graders rose four points, and fourth graders' scores rose less than one point. The significant Grade X Training Group X Test Session interaction showed that training was most effective at the first and second grade levels. The ratio of mean score increase of the non-trained to the trained group was as follows: 4:7.5 for grade 1; 2:7.6 for grade 2; 2.5:6 for grade 3; and -.4:2 for grade 4.

Insert Tables 6 and 7 about here

Relationship of Series Scores to Race and Social Class

For each town except Hartford, for which social class information was not available, percentages by race and social class were obtained (Table 8). Social class was determined by father's occupation, with the scale employed by Project Talent (Flanagan & Cooley, 1966, pp. E-11). Middle class was defined to include managers and professionals and lower class to include laborers and skilled and semi-skilled workers. It can be seen in Table 8 that the Hartford and Stamford students were predominantly black and lower class, while the large majority of Westport, Darien, Ledyard, and Wilton students were white and middle class. Although social class data for Hartford students was not

TABLE 6

Means on Series Pretest and Posttest of Trained and Nontrained Subjects in Training Study (N = 471)

	Trained			Nontrained		
	Pretest	Posttest	Difference	Pretest	Posttest	Difference
Grade 1	21.17	28.63	7.46	21.12	25.49	4.37
Grade 2	31.35	38.98	7.63	33.02	34.96	1.94
Grade 3	37.53	43.72	6.19	36.90	39.40	2.50
Grade 4	37.72	39.68	1.96	40.44	40.04	-.40

Table 7

Repeated Measures Analysis of Variance Results for Training Study[a]

Source	Sum of squares	df	Mean square	F
Grade	33654.047	3	11218.016	36.542**
Group (trained vs. nontrained)	183.409	1	183.409	0.597
Form (test form)	287.081	1	287.081	0.935
Grade X Group	481.404	3	160.468	0.523
Grade X Form	205.368	3	68.456	0.223
Group X Form	406.628	1	406.628	1.325
Grade X Group X Form	165.085	3	55.028	0.179
Unit	139681.375	455	306.992	
Test	3360.535	1	3360.535	94.965**
Grade X Test	793.010	3	264.337	7.470**
Group X Test	739.068	1	739.068	20.885**
Form X Test	6.364	1	6.364	0.180
Grade X Group X Test	82.004	3	27.335	0.772
Grade X Form X Test	284.031	3	94.677	2.675*
Group X Form X Test	8.017	1	8.017	0.227
Grade X Group X Form X Test	200.189	3	66.730	1.886
Test X Unit	16101.148	455	35.387	
Total	196638.375	941	208.967	

[a]An unweighted means solution was used.

*$p < .05$

**$p < .001$

available, the Hartford school from which this sample was drawn is in an inner city black area.

Insert Table 8 about here

Since the correlation between scores on the two Series forms was high but the pretest mean on Form B was 2.14 points higher than that on Form A, scores on both forms were pooled and the 2.14 difference was added to scores on Form A. Graphs were drawn to show the mean pre to post differences on these pooled, form-adjusted Series scores for the trained and non-trained groups in each grade level in the predominantly middle and lower class towns. In these graphs Hartford and Stamford students' scores were combined. Similarly, Darien, Ledyard, and Wilton students' scores were combined, to investigate further possible social class differences.

Figure 1 shows that on the Total Series, training resulted in the greatest mean score increase for second and third graders in the lower class communities. In the middle class towns, first and second graders showed the highest mean increase. The fact that fourth graders improved little with training, regardless of social class, revealed a ceiling effect of the test; i.e., training did not appear to be beneficial after the third grade.

Insert Figure 1 about here

For the 15 matrix items the results for the lower class sample were about the same as those on the total test. The middle class trained students showed the greatest increase on these items in the second and fourth grades, while the non-trained first graders improved more than the trained first graders. The Picture Series and Geometric Series graphs were very similar to the graph for the total test, reinforcing the notion that training did not greatly contribute to better performance after the third grade. On the Geometric Series Subtest, in fact, the non-trained middle class fourth graders showed a greater pre to post increase than the corresponding trained group.

Additional analysis of social class differences was performed by computing the pretest mean on the form-adjusted total Series scores for middle class students in the four predominantly middle class communities (Westport, Ledyard, Wilton, and Darien). The percent of students falling above and below this mean before and after training was calculated by social class in each town. The aim of this analysis was to determine whether lower class students attained a Series score after training which was equal to or above the average initial scores of middle class students.

Table 8

Race and Social Class Percentages by Town

	Race			Social Class					
	White	Black	N	Laborers	Semi-skilled	Skilled	Managers	Professionals	N
Westport	83.3	16.7	102	9.3	8.0	24.0	34.7	24.0	75
Darien	100.0	0.0	328	1.6	3.9	15.2	52.9	26.5	257
Hartford	1.3	98.7	155	---	---	---	---	---	---
Ledyard	99.7	.3	289	1.1	3.2	28.9	25.8	41.1	190
Wilton	97.6	2.4	207	0.0	4.3	6.1	58.3	31.3	163
Stamford	23.8	76.2	479	36.2	31.7	24.9	6.0	1.2	334

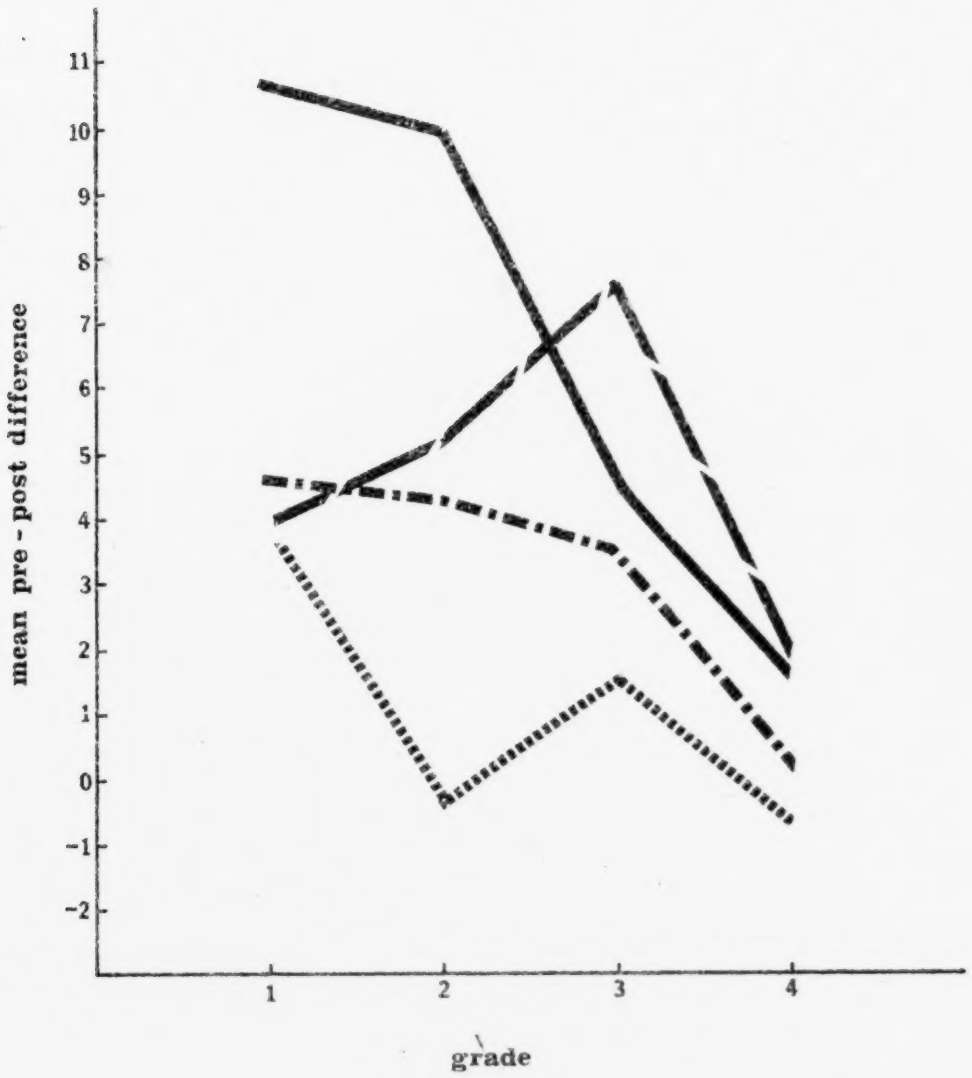

Fig. 1. Mean Pre- to Posttest Difference of Trained and Nontrained Subjects of Total Series Test.

Table 9 presents Series scores before and after training by social class for each town. It was anticipated that scores of lower class children could be raised with training to equal the pretest scores of middle class children. For the total sample, this result occurred for children of skilled workers but not for children of laborers or semi-skilled workers, although these latter two groups improved considerably with training. It is noteworthy that within each town the expected result was achieved in all communities except Wilton, where the discrepancy between initial scores of lower and middle class students was the greatest. After receiving training, 42.4% of the trained students in Hartford, which was largely black and lower class, surpassed the pretest mean of middle class students; only 26.4% surpassed this mean before training. Of all lower class students in the sample (with Hartford included), 51.3% exceeded the middle class pretest mean after training, in contrast to 34.9% who surpassed this mean before training.

Insert Table 9 about here

The relative contributions of race, social class, and race-social class interaction to Series performance before and after training were examined by using these three independent variables in two stepwise multiple regression equations. In the first equation the adjusted pretest score was the dependent variable; in the second equation, the adjusted posttest score was the dependent variable and the adjusted pretest score was entered before the other three variables. The unique variance contributed by each independent variable in the equations was determined.

Table 10 shows the results of the stepwise multiple regressions on Total Series scores before and after training. Social class contributed the most to pretest scores ($r^2 = .05$), although the unique variance of race and race-social class interaction were also significant. The pretest score accounted for 52.3% of the variance in scores after training. With pretest score held constant, social class was the best predictor of posttest score ($r^2 = .05$), although the other variables were again significant.

Insert Table 10 about here

Relationship of Series Scores to IQ

Means and standard deviations were calculated on four separate IQ test scores. Scores from these tests were

Table 9

Series Scores by Social Class before and after Training

	Before training			After training		
	% below mean[a]	% above mean[a]	N	% below mean[a]	% above mean[a]	N
Total sample						
1. laborers	67.0	33.0	134	58.5	41.5	106
2. semi-skilled	67.4	32.6	135	53.0	47.0	102
3. skilled	53.7	46.3	205	35.4	64.6	178
4. managers	38.0	62.0	326	14.0	86.0	284
5. professionals	33.7	66.3	219	11.3	88.7	169
Westport						
Lower class[b]	48.4	51.6	31	33.3	66.7	30
Middle class	34.1	65.9	44	14.6	85.4	41
Darien						
Lower class	52.8	47.2	53	33.3	66.7	48
Middle class	45.6	54.4	204	12.4	87.6	170
Ledyard						
Lower class	30.2	69.8	63	14.5	85.5	55
Middle class	30.7	69.3	127	12.9	87.1	101
Wilton						
Lower class	58.8	41.2	17	35.7	64.3	14
Middle class	23.3	76.7	146	8.3	91.7	121

Table 9 (continued)

	Before training			After training		
	% below mean[a]	% above mean[a]	N	% below mean[a]	% above mean[a]	N
Stamford						
Lower class	70.6	29.4	310	58.6	41.4	239
Middle class	70.8	29.2	24	45.0	55.0	20
Hartford						
Lower class	73.6	26.4	201	57.6	42.4	99

[a]Mean was calculated from pretest scores of children in Westport, Darien, Ledyard, and Wilton whose fathers were managers or professionals.

[b]Lower class comprises categories 1 to 3; middle class comprises categories 4 to 5.

Table 10

Results of Stepwise Multiple Regressions on Series Scores

I. Dependent Variable: Series Pretest Score

Source	df	% variance	Mean % variance	F
Race (unique)	1	.008	.008	14.92*
Social Class (unique)	1	.051	.051	95.09*
Race X Social Class (unique)	1	.025	.025	46.61*
Common Variance (Race + Social Class + Race X Social Class)	(1)	.030	.030	55.94*
Total variance accounted for	(3)	.114	.038	70.85*
Error	1652	.886	.000536	

II. Dependent Variable: Series Score after Training

Pretest (unique)	1	.324	.324	972.97*
Race (unique)	1	.009	.009	27.03*
Social Class (unique)	1	.050	.050	150.15*
Race X Social Class (unique)	1	.019	.019	57.06*
Common Variance (Race + Social Class + Race X Social Class)	(1)	.204	.051	153.15*
Total variance accounted for	(4)	.606	.152	456.46*
Error	1181	.394	.000333	

*$p < .001$

treated separately for two reasons: (a) since students in different towns had received different tests, the type of test was confounded with town and therefore with social class, and (b) correlation coefficients among the Kuhlmann-Anderson, the Otis, and the Lorge-Thorndike are only moderate, ranging from .41 to .67, depending on the form given (Technical Manual, 1963, pp. 17-18; Lorge & Thorndike, 1962, p. 21). No IQ information was available for Hartford students.

To assess the relationship of IQ and Series scores, correlation coefficients were obtained between each of the four IQ test scores and adjusted Series scores before and after training. In addition, four multiple regressions were run in which the adjusted posttest score was the dependent variable and the adjusted pretest score and scores on one IQ test were the two independent variables. Pretest score was entered first and the unique variance contributed by each IQ score was determined.

Table 11 shows the means, standard deviations, correlations with Series total scores, and unique variance contributed to Series scores after training for each of the four IQ tests. It can be seen that the mean IQ in Stamford (where the sample was predominantly black and lower class), was considerably lower than the mean IQ in the middle class towns. All four test scores correlated significantly with Series scores before and after training. With the variance due to the pretest removed, results of the regressions showed that all IQ scores except the Otis contributed significantly to performance after training.

Insert Table 11 about here

Relationship of Series Scores to Reading and Vocabulary Scores

The relationship of Series scores to comprehension and vocabulary scores on the Gates-MacGinitie Reading Test can, in one sense, be considered evidence of concurrent validity of the Series Test. It must be recognized, however, that the former is a verbal test and the Series Test is nonverbal.

Initially, the form-adjusted pretest and posttest scores on the Series were correlated with the two Gates-MacGinitie subtest scores. Stepwise multiple regression equations were then formulated, with comprehension and vocabulary scores as the dependent variables. Independent variables were entered into each equation in the following order: IQ, social class, race, social class-race interaction,

TABLE 11

IQ Means, SDs, and Correlation Coefficients with Series Scores

	Lorge-Thorndike Multi-level	Lorge-Thorndike K-3	Kuhlmann-Anderson	Otis
Where given	Westport, Darien, Ledyard	Stamford	Wilton	Ledyard
Mean	112.06	90.48	119.20	116.28
Standard deviation	11.62	12.41	15.10	14.13
r_{Series} before training	.334**	.356**	.317*	.404**
r_{Series} after training	.375**	.363**	.391**	.306**
Unique r^2 on posttest after training	.027**	.024**	.035**	.001
Minimum N	116	210	78	118

*p <.01

**p <.001

membership in a reading enrichment program (CIRP)[1], and Series pretest score. The order of entry of these variables was determined by hypotheses concerning the relationship between each variable to the dependent variable, as well as by previously demonstrated statistical relationships among the independent variables. Five equations were constructed for both dependent variables, one for each type of IQ test given to different groups of students.

Pearson product-moment correlation coefficients between Series and Gates-MacGinitie scores are presented in Table 12. Fisher's r to Z transformation was used to obtain the 95% confidence interval of the two coefficients between reading comprehension and Series scores before and after training. Since these two confidence intervals did not overlap, the relationship between reading comprehension and Series scores after training was significantly higher than that before training. On the vocabulary measure, however, the confidence intervals of the two coefficients overlapped a .05 interval. Although the relationship between Series and vocabulary scores increased after training, this increase was not statistically significant.

Insert Table 12 about here

Results of the multiple regression analysis are presented in Table 13. Score on the group IQ tests, regardless of the test used, was found to be the best predictor of both comprehension and vocabulary scores. Social class was also a significant predictor in all ten equations. Race, race-social class interaction, and membership in a reading enrichment program (CIRP group) were significant in several equations, although these variables accounted for a relatively low percent of the variance in both dependent variables.

Insert Table 13 about here

Despite the low contribution to total variance of race and CIRP group, it should be noted that in Equation 2 for comprehension (Westport, Darien, and Ledyard) signs of the t-tests for race and CIRP were in the opposite direction of those in other equations in which these variables were significant. That is, blacks and nonCIRP students tended to have higher comprehension scores in this analysis, whereas whites and CIRP students had higher scores in some of the other analyses.

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[1]The Cooperative Individualized Reading Project (CIRP) was a reading enrichment program designed to improve reading achievement. CIRP was conducted concurrently with this study, and students in some classrooms were participating in both studies.

TABLE 12

Pearson Product-Moment Correlation Coefficients between Series and Gates-MacGinitie Scores

	Gates-MacGinitie		
	Comprehension	Vocabulary	N
Series pretest	.471*	.326*	1228
Series posttraining	.592*	.429*	954

*p <.001

TABLE 13

Multiple Regression Results with Gates-MacGinitie Scores

	Equation 1		Equation 2		Equation 3		Equation 4		Equation 5	
IQ test	All 4 tests pooled		Lorge Multi-level		Lorge K-3		Kuhlmann-Anderson		Otis	
Where given	Westport, Darien, Ledyard, Stamford, Wilton		Westport, Darien, Ledyard		Stamford		Wilton		Ledyard	
Dependent variable = Gates MacGinitie Comprehension										
Independent variable	% var.	T	% var.	T	% var.	T	% var.	T	% var.	T
IQ	.131	17.53***	.135	17.93***	.099	14.88***	.246	27.06***	.105	15.38***
Social Class	.016	6.13***	.100	15.42***	.065	12.05***	.063	13.70***	.029	8.06***
Race (0=white; 1=black)	.009	-4.58***	.002	2.27*	.000	.10	.000	.48	.013	-5.35***
Social Class X Race	(.000)[a]	--	.020	-6.89***	.013	-5.37***	.012	-6.02***	.000	-.45
CIRP (0=nonCIRP; 1=CIRP)	(.000)[a]	--	.006	-3.63***	.001	1.54	.007	4.66***	(.000)[a]	--
Series Pretest	(.000)[a]	--	(.000)[a]	--	(.000)[a]	--	(.000)[a]	--	(.000)[a]	--
df		1310		1308		1308		1308		1309
r^2	.441		.449		.413		.560		.418	
Dependent variable = Gates MacGinitie Vocabulary										
IQ	.147	20.13***	.065	12.50***	.150	21.22***	.196	24.57***	.168	22.04***
Social Class	.028	8.84***	.117	16.74***	.075	15.04***	.089	16.55***	.034	9.90***
Race	.007	-4.33***	.000	.33	.000	.68	.000	-.46	.018	-7.28***
Social Class X Race	(.000)[a]	--	.010	-4.95***	.014	-6.41***	.008	-5.05***	.000	.68
CIRP	(.000)[a]	--	.004	3.16**	.031	9.70***	(.000)[a]	--	(.000)[a]	--
Series Pretest	(.000)[a]	--	(.000)[a]	--	.000	.91	(.000)[a]	--	(.000)[a]	--
df		1317		1315		1314		1316		1316
r^2	.522		.451		.562		.572		.544	

[a]The % of variance accounted for by this variable was so small that the variable was not entered into the equation.

*p <.05

**p <.01

***p <.001

Series pretest score accounted for so little variance that it entered into only one equation, in which the t-test of its beta weight was only .91 and not significant.

The Series Test, then, was significantly correlated with Gates-MacGinitie comprehension and vocabulary scores, when only the zero order correlation is considered. Since both the Series Test and the Gates-MacGinitie were found to be related to IQ, social class (and less so to race), when these demographic characteristics are taken into account the relationship between Series and Gates-MacGinitie scores becomes negligible. In other words, a child who is middle class, white, or has a high IQ usually tended to do better on the Gates-MacGinitie tests regardless of his performance on the Series. As has been pointed out previously, it is this same child who attained a high Series score as well.

Discussion

The two forms of the Series Test proved to be highly reliable, both in internal consistency and over time. Equivalence of forms was demonstrated by high alternate-form correlation coefficients, parallel item loadings on the first principal component, parallel item difficulties, and lack of significant difference for test form in the training study analysis.

Factor analysis empirically confirmed only the Picture Series as a distinct entity, casting doubt as to the appropriateness of separate scores on the other three subtests. Training had little effect on the factor structure and on the difficulties or principal component loadings of very difficult items.

Students who got the highest scores both before and after training came from a high socio-economic background, were white, and generally had high IQ scores. Training, however, was able to boost the mean scores of lower class students to the pretest level of middle class students in five of the six towns analyzed.

A ceiling effect was demonstrated by both the training study analysis and the graphs contrasting scores of middle and lower class groups. Training was most effective for second and third graders in lower class towns and for first and second graders in middle class towns. These analyses suggest that the training on the Series Test is of little benefit beyond the third grade and, for middle class students, beyond the second grade.

To explore the question of a ceiling effect further, the Series Test was given to seven adult college graduates. All got nearly perfect scores; those items answered incorrectly were the items with the lowest difficulty levels in the present analysis. It would appear then, that some items in the Series Test as presently constructed are geared toward a highly educated test-taker, while others are appropriate for children in the primary grades. This theory could explain why the four factors accounted for only a third of the variance in scores attained by the first through fourth grade students in this sample.

Because of the ceiling on Series Test scores, and because of the relationship of Series scores to race and social class, the Series Test appears to be a less useful measure of learning potential than either the Kohs Block Designs or the Raven Progressive Matrices.

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Footnotes

[1]This research was supported by grant OEG-0-8-080506-4597 from the Bureau of Education for the Handicapped, U.S. Office of Education, Department of Health, Education, and Welfare. The Series Test was developed by Dr. Elisha Y. Babad who is currently affiliated with the Department of Psychology at the Hebrew University of Jerusalem in Israel. The authors wish to thank Dr. Robert H. Harrison for statistical consultation.

Instructions for Administration of the Series Learning Potential Test

For successful administration of the Series Learning Potential Test, the examiner must arouse the curiosity and involvement of the subjects simultaneously by creating a relaxed atmosphere in which the challenge is non-threatening to the children. The test (called "The Series Game") lends itself well to these requirements due to its game-like nature. The coaching session is an opportunity for loose, active involvement, while the post-test is an opportunity for a more relaxed second effort at the task.

The Series Learning Potential Test is administered in three separate sessions - the pre-test is administered on the first day, the coaching on a second day, and the post-test on a third day (within three days, or within the range of a week for the cycle of testing). The schedule of these sessions should not interfere with "popular" activities such as gym and art. In the case of younger groups (ages 7 - 9) it is recommended that the sessions be held early in the day. The test should be given in a room free of distractions, and the children should be seated so they can watch the examiner. Also, there should be enough space for the examiner to walk among the subjects. The optimal size of the group is between 8 and 15 subjects. An experienced tester can sometimes manage a group of 25 to 30 children. With young children, it is highly recommended to have no more than 10 - 12 subjects in the group. When testing large groups (if this is unavoidable) the tester should be assisted by a person who is familiar with the Learning Potential measurement in all three parts of the testing. The test user should try to test the group in their usual classroom and to have the teacher present (even though she need not participate in the administration).

With the setting arranged, it's up to the examiner to make the situation interesting and relaxed. The examiner should explain to the subjects what to expect in each session. The terminology should be simple, referring to test items as puzzles and to the coaching as the "game of learning tricks" for greater enjoyment the second

time around. We recommend that the tester should try to pick up the names of the children early in the session.

During the testing, the examiner should walk around the room to make sure instructions are understood and followed. Occasionally the tester should reinforce individual children by saying "good" or "that's right" or give individual attention to children who seem to be nervous or have difficulties, i.e., repeat test instructions. It is probably better to exclude resistant and/or hyperactive children than making them take the test in an orderly way against their will.

Specific Instructions

Pre-Test Instructions

Once all the subjects have settled down with erasers and sharpened pencils, the examiner makes her introductory remarks. These comments refer to the test items as puzzles or games, and emphasize that the subjects will later be shown tricks which enable them to play the game better a second time. These comments could be flexibly changed to suit the group addressed.

"Today you're going to do the puzzles in the Series Game book (indicate pre-test booklet). First you will do them on your own, and later I'll show you tricks you can use for solving the puzzles. The next time I come you'll work on puzzles like these again on your own, so you'll have a chance to use the tricks."

Pass out the test booklets and ask the subjects to fill in their first and last names, etc. Spell out the teacher's name on the blackboard and point to the appropriate lines on the face sheet as the subjects are writing. Walk around the room to see that the writing is legible and that both first and last names have been written. Return to the front of the room where all the subjects can see clearly. When all the children are ready, give the pre-test instructions, holding the test booklet up to demonstrate the directions.

You explain to the subjects the nature of the stimuli and the requirements of the task - to find the picture that belongs in the empty space, and circle it. Your instructions should clearly distinguish between the puzzle row (the series itself) and the answer options.

"Now turn to page one and look at the first row. What do you see? You see a series of pictures and an empty space. What you have to do is find the picture that belongs in the empty space. That picture is one of the pictures on this side of the page (right side). So this row on the left, is the puzzle (point) and these are the choices (point). Only one of these pictures fits in the empty space, and you must find which one is the best. Look at the pictures in the puzzle and ask yourself, 'What comes next, what fits in the empty space?' then look at the choices and circle the picture you think is the right answer. Which of the choices is the right answer for the first row? Is it number 1, 2, 3, or 4? (Point to each of the numbered choices). That's right, it's number 3. Put a circle around number three. (Walk around the room to be sure each child has done it correctly). Now you can do the rest of the book by yourselves the same way. Each row is a different puzzle which has a different answer. Look at the puzzle with the empty space, ask yourself what picture comes next and fits in the empty space. Then look at the choices and circle the right answer. Remember that there is only one right answer. Be sure not to skip a row."

The test lasts for 30 minutes or until all but one or two subjects have finished. During the test, walk around the room to be sure that the subjects circle only one answer, that they do not circle pictures in the series puzzle itself, and that they do not consistently circle the same position. You can repeat the instructions and reinforce children, but do not offer any information beyond what you have given in the initial instructions.

Coaching Instructions

The coaching session, administered to the entire tested group, provides "tricks" for approaching picture series problems. The group learns to approach, and solves together, seventeen items. The following principles are emphasized:

1. In each series "something changes," and one must identify the change in characteristic (e.g., changes in object, size, color, etc.).
2. The change in every series has a "tune," or "rhythm." One

must discover the tune and be able to sing it to himself. Using the tune, one can go beyond the pictures in the series.

3. Most series have more than one "tune;" one must first identify the different "tunes," and then sing each separately. Each isolated "tune" will include only one change dimension.

4. For every "tune"one sings, he can cross out those choices which are incorrect for that tune. The remaining uncrossed choices can help decide which "tune" to sing next.

5. "Tunes" must not start at the beginning of the series, and they can be sung in any direction.

In short, the tester coaches the subjects to identify the concepts (color, size, object, etc.) which change in a series using their sense of rhythm, to isolate the concepts by separating the tunes, and to eliminate wrong choices for each step. Emphasize the point of looking to see what changes - of saying a separate tune for each thing that changes.

The coaching session should be carried out as a group experience that involves all subjects. Distribute the booklet entitled "Tricks for the Series Game." Inform the children about it and ask them not to proceed ahead of the group. The coaching is carried out much as a regular lesson, and the children should be encouraged to "sing the tunes" together. At the same time, you should call on individuals (active and passive, bright and less bright) to lead the class in identifying and singing the tunes.

A set of complete instructions for the coaching booklet follows. With slower groups, the instructions should be followed to the letter. With other groups, the tester should use his judgment to determine the amount of repetition. "Repetition" refers mostly to the number of times the same tune is repeated. If the group shows signs of boredom and most subjects seem to catch on to the strategies, the tester should skip a few items, e.g., numbers 13, 14 or 15. In any case, the last item should be included in coaching as it shows the use of starting the tune at the end of the series.

Instructions for Coaching

"In the booklet that you just completed, you saw rows of pictures

with an empty space in each rown. You had to find the picture that fits the empty space and completed the series and then circle it. Now we will go through this booklet together and I will show you some tricks that will help you find the right answer for each row. If you use these tricks, the problems will be very easy. Look at the first row in "Tricks for the Series Game." What do you see? (Tester should encourage a group response here and in the following problems but at the same time should also learn some of the subjects' names and call on specific individuals at times. The subjects must answer with the coacher and not go be ond the example with which the coacher is dealing. The use of the strategies must be enforced in this way.) That's right, a row of flowers. Now let's look at the same row again and as we look we can say what each picture is (point to each picture as you go along saying the name of the picture aloud) flower, flower, flower, flower, flower, flower. We can say that the tune is flower, flower, flower, flower, flower, flower. (Go through the series saying the tune aloud with the subjects once more and when you reach the empty space ask what goes here.) Let's repeat the tune of the row once together (this time continue the tune to automatically extend beyond the empty space). So now we see that flower fits in the empty space. Now look at the choices on the other side. We know it can't be number 2 because that's an apple. Cross it out. (Tester should walk between aisles to make sure everyone gets the idea of crossing out the wrong answers.) Is it number 1? No. Why? That's right, it's too small. Cross out number 1. What's left? The big black flower and the small white flower. Which one is the right answer? That's right, number 3 is the right answer. Circle it.

"Now look at row number 2. What do you see? Yes, there are teddy bears and clocks, two different kinds of pictures. Let's go through the row and say the tune. Teddy bear, clock, teddy bear, clock, teddy bear, clock. (To the coacher: do you feel the tune? Tune must be read rhythmically to catch the class's interest.) Once more, teddy bear, clock, teddy bear, clock, teddy bear, what goes here? That's right - clock. Now look at the choices. Since we

know the right answer is a clock which answers do we know are wrong? Yes, we know that number 1 and 3 can't be right because they're both teddy bears, so cross them out. What's left? The small clock and the big clock. Is it number 2? No. Why? It's too small. Cross out number 2. Now what's left? The big clock, number 4. This is the right answer so circle it. (Be sure the children pick up the rhythm. You might move your hands in time to the rhythm as you say the series out loud with the kids. Coacher should emphasize questioning the class but at the same time should call on individuals whose attention might be wandering. Coaching must be made exciting but must not move so quickly that the slower children are lost.)

"In the next few problems I will show you that there are different kinds of tunes which we must look for in the rows. We have just seen that the picture can change from teddy bears to clocks. In row number 3 we see a different kind of change. Can someone tell me what changes here? That's right, the color changes from black to white. Does the picture change? No. All the pictures are birds so we are just going to forget about the pictures and look at the color tune. Remember we done't say bird each time, we just say the color. (Tester should make sure everyone just says color to avoid confusion later on when more than one tune are present.) Let's say the color tune. White, black, white, black, white, black. (Tester should always continue the tune beyond the empty space.) Again. White, black, white, black, white, what comes next? That's right - black. Black is the right answer so which of the choices can we cross out? Number 2 and 3 - because they're white. What's left? The big black bird and the small black bird. Which is the right answer? Number 1 is the right answer because all the birds are big. Cross out number 4 then and circle number 1.

"Turn the page. Now let's look at row 4. What do you see? You see a row of balls, so we know the picture doesn't change. What changes? That's right - size. The balls are big and small. Does color change? No. Now let's read through the row and say the size tune. Remember we don't have to say ball each time because we're just looking at the size tune. Big, small, big, small, big, small.

(Tester should always continue the tune beyond the empty space.) One more time. Big, small, big, small, big, what comes next? Small. Now let's look at the choices. We know that the answer has to be small so which ones can we cross out? That's right - we can cross out numbers 2 and 3 because they're both big. What's left? The small black ball and the small white ball. Which is the right answer? That's right. The small white ball because all the balls are white, so cross out number 1 and circle number 4.

"What do you see in row number 5? Yes, there are pictures of a flower, a dog and a man. We've seen rows with one kind of picture and rows with two kinds of pictures. Now there are three kinds of pictures in this row. Does the color change? No. Does the size change? No. Something else is different. Can someone tell me what it is? Yes, the empty space comes in the middle of the line and not at the end. This makes the problem a little harder but we use the same tricks. Let's read the tune together. Flower, dog, man, flower, dog, man, flower, dog, man. Again. Flower, dog, man, flower, dog, man, what comes next? That's right - a flower. Let's look at the choices. We know that a flower is the right answer so what can we cross out? Yes, we can cross out everything except the flower, number 3, the correct answer. Now circle the flower. Now let's review. What are the things that can change? That's right. Color, size, picure. That means there can be three separage tunes.

"Let's look at row 6. What changes? Size. Does anything else change? No. Let's read the size tune. Big, small, small, big, small, small, big, small, small. (Even if the written series is not complete, tester should always read a complete tune.) One more. Big, small, small, big, small, what comes next? That's right - small. Look at the choices. What can we cross out? We can cross out number 2 and 3 because they're both big. Now which answer is the correct one? Number 1 is right. Why not 4? It's facing the wrong direction. Circle number 1.

"What changes in row number 7? That's right - the pictures change. Does color change? No. Does size change? No. Where's the empty space this time? That's right, the empty space comes in the beginning. Here's the trick when the empty space comes first.

Start at the end of the row instead of at the beginning when we read the tune. Let's read the tune together going from the end. Lady, lady, bird, ball, lady, lady, bird, ball. Again. Lady, lady, bird, ball, lady, lady, bird, what comes next? That's right - ball. Ball is the right answer. Let's look at the choices. Which ones can we cross out? We can cross out number 1 and 4 because they're birds and number 3 because that 's a lady. What's left? Ball. Put a circle around number 2. That's the correct answer - ball.

"Now let's look at row number 8 and see what changes here. Can someone tell me what changes? Yes, the position changes. Some hands go up and some go down. Does anything else change? No. Then let's go through the row reading the tune for position and saying only up or down for each picture. OK, the first one goes up so we say up, down, up, down, up, down. Let's go through the series once more. Up, down, up, down, up, down. What fits in the empty space? That's right - we need an up. Now look at the choices. Which ones can we cross out? Yes, cross out 2 and 3 because they go down. Now, which is the right answer? Yes, 1 is the right answer so cross out number 4 and circle number 1. Why is 4 wrong? That's right - it's facing the wrong way.

"Now we see that there are a number of things that can change in a row: the size, the picture, and the color and position. (in the following rows in which there are more than one of these tunes, the coacher should always stress that he prefers the subjects to start with color, size, or position and end with picture. Thus the subjects will learn to look for all tunes and not stop after reading the most obvious - the picture tune.) In row 9 we are going to see that sometimes more than one thing changes in a row which means we have to look for more than one tune in the row. For example, things can be black and white and also big and small, so now we will look at each kind of change separately and then it will be easy to find out what the right answer is. Now when we look at a series we will find all the kinds of changes there are and then we will look at each one separately. Look in row number 9. What kinds of changes do you see? That's right, the kinds of

pictures change. There are teddy bears and dogs. What else changes? Yes, the color changes from black to white. Does anything else change? No. Let's just look at the color change first. Can someone read the tune for color? White, black, white, black, white, black, white, black. Again. White, black, white, black, what comes next? Yes, white. Now let's look at the choices. Which ones can we cross out? Yes, we can cross out numbers 2 and 4 because they are black. What's left? A dog and a teddy bear. Now let's go back and read the picture tune so we can choose the right answer. Teddy bear, teddy bear, dog, dog, teddy bear, teddy bear, dog, dog. Once more. Teddy-bear, teddy bear, dog, dog, what comes next? That's right - teddy bear. Now look at the choices. Cross out the dog and circle the right answer, the teddy bear.

"Now look at row number 10. What kinds of changes do you see? That's right - the pictures change from keys to planes. What else changes? The size. Does anything else change? No. Let's look at the size tune first. Big, big, small, small, big, big, small, small. Once more. Big, big, small, small, big, big, small, what comes next? That's right - small. Now look at the choices and what can we cross out? Yes, we can cross out numbers 1 and 4 because they're big and we want a small for the empty space. What's left? A key and a plane. Now we must go back and read the tune for pictures to decide between the key and the plane. Key, plane, key, plane, key, plane, key, plane. Again. Key, plane, key, plane, key, plane, key, what comes next? That's right - a plane. Now we can cross out the key and circle number 3, the plane.

"Look at row number 11. What do you see? Apples. Does the picture change? No. What changes then? The size. What else? The color. Now let's look through the row saying the color tune. White, white, black, white, white, black, white, white, black. Let's read it once more. White, white, black, white, white, black, white, what comes next? Yes, white. Now look at the choices. We know that the right answer is white so which ones can we cross out? That's right - we can cross out numbers 1 and 2 because they're black. What's left? A big apple and a small apple. Now we must go back through the row once more to decide on the right answer. This time

we will read the tune for size. Big, big, big, small, small, small, big, big, big. Once more, big, big, big, small, small, small, big, what comes next? Yes, big is right. Now we can cross out the small apple and circle the big apple, the correct answer.

"Now let's go to row 12. What changes here? Yes, the picture changes from cats to boys. What else changes? Yes, the size changes. Does the color change? No, they're all white. Does the position change? No. Then let's start with the tune for size. Can someone say the tune for size? (The coacher must constantly check the extent of participation and call on the inattentive ones. No one should be lost at this stage of the coaching.) Big, big, big, small, small, small, big, big, big. Again. Big, big, big, small, small, small, big, big, what comes next? That's right - big. Now look at the choices. Which ones can we cross out? That's right - cross out numbers 2 and 4 because they're small and we need a big. What's left? A cat and a boy. Now we must go back and read the tune for picture to decide on the correct answer. Cat, boy, cat, boy, cat, boy, cat, boy, cat. Again. Cat, boy, cat, boy, cat, boy, cat, boy, what comes next? That's right - a cat. So now we know that number 1, the large cat is the right answer. Circle number 1.

"Now look through row 13. Tell me what changes. That's right - the picture changes. There are birds and cats. What else changes? Color changes. There are whites and blacks. What else? That's right - size changes. Does anything else change? No. So in this row we can see that we have three different tunes that we must do separately. Now let's go through the row looking at the size first. Big, big, small, big, big, small, big, big, small, big, big, small. You see I say big and small without looking at what the picture is or what the color is. Then I will go back and look at each of those tunes separately. Let's say the size tune once more. Big, big, small, big, big, small, big, big, small, what comes next? That's right, big. Now look at the choices. Which ones can we cross out? Yes, we can cross out numbers 2 and 5 because they're small. Now let's go back through the row reading the tune for color. White, black, white, white, black, white, white, black, white,

white, black. Once more. White, black, white. white, black, white, white, black, white, what comes next? That's right - white. Now look at the choices and what other ones can we cross out? Yes, we can cross out numbers 3 and 4 because they're black. What's left? A cat and a bird. So now let's read the tune for pictures to decide on the right answer. Bird, bird, bird, cat, cat, cat, bird, bird, bird, cat, cat, cat. Again. Bird, bird, bird, cat, cat, cat, bird, bird, bird, what comes next? That's right, cat. So cross out the bird and circle the correct answer, the cat, number 1.

"Now let's look at row 14. When the blank is at the beginning, what trick do we use? That's right - we start at the other end. Now what are the different changes in row 14? Size changes. Color changes. Picture changes. That's right. Let's start with the color tune this time. Remember we are going to read each tune separately. Black, black, white, white, black, black, white, white. Again, black, black, white, white, black, black, white, what comes next White - that's right. Now let's look at the choices. Which ones can we cross out? Numbers 1, 3, and 6 because they're black and we need a white. Now let's go back and read the size tune. Small, small, big, small, small, big, small, small, big. Again. Small, small, big, small, small, big, small, what comes next? That's right - small. Now if we look at the choices again we see that we can cross out number 2 because we want a small and number 2 is big. Finally let's go back and read the picture tune. Ball, flower, ball, flower, ball, flower, ball, flower. Again. Ball, flower, ball, flower, ball, flower, ball, what comes next? Flower - that's right. Now let's look at the choices again. What's left? A ball and a flower. Which one is the correct answer? The small white flower, number 3 is the correct answer so cross out the small white ball and draw a circle around number 3.

"Now look at row 15. What changes in this row? The kinds of pictures change. There are books, cars, fish and dogs. What else changes? The size changes. Does anything else change? No. Now let's look through the row saying the tune for size only. Big, small, small, big, big, small, small, big, big. Again. Big, small, small,

big, big, small, small, what comes next? Big is right. Look at the choices and tell me what we can cross out. Yes, we can cross out all the smalls, numbers 4, 5 and 6 because we need a big for the empty space. What's left? A fish, a dog and a book. Now we must go through the row once more reading the tune for pictures. Book, book, car, car, fish, fish, dog, dog. Again. Book, book, car, car, fish, fish, dog, what comes next? That's right - dog. Now we know that the right answer is a dog so we can cross out the fish and book and circle number 3, the big white dog.

"Turn to the last page and look at row number 13. What changes here? Pictures. Color. Size. Yes, that's right. So we know that there are three different tunes that we must do separately. Let's begin with the size tune. Big, small, big, small, big, small, big, small, big, small. Again. Big, small, big, small, big, small, what comes next? Big, that's right. Now let's look at the choices. Which ones can we cross out? Number 3 and 5 because they're small and we want a big. Now let's go back and read the color tune. White, white, black, black, white, white, black, black, white, white. Again. White, white, black, black, white, white, what comes next? That's right - black. Now which choices can we cross out? Number 2 can be crossed out because that's white. What's left? Apple, flower and a bear. Now we must read the picture tune to decide on the right answer. Bear, apple, flower, bear, apple flower, bear, apple, flower, bear, apple, flower. Again. Bear, apple, flower, bear, apple, flower, what comes next? Bear is correct. Now we can cross out the apple and the flower and circle the correct answer, number 6, the big, black bear.

"Let's look at the last row - number 17. What changes in this row? The kinds of pictures change. Does anything else change? That's right just the kinds of pictures change. So let's look through the row now at the pictures. We see that there are girls, houses, and cats. Three different kinds of pictures. Now let's look through the row and see how the tune sounds. (This last example is a particularly good row to ask an individual to do alone, especially if there is one child who thinks he understands all the

strategies to a point of impatience with the tester. If the child makes a false start, suggest that he start from the other end and remind him that the tune contains three different pictures. When he says the tune correctly, repeat it with the whole class.) Girl, house, girl, cat, girl, house, girl, cat, girl, house, girl, cat. Let's say it once more together. Girl, house, girl, cat, girl, house, girl, cat, girl, house, girl, cat. What picture are we missing in the series? Cat is correct. Now if we look at the choices below, we can see that numbers 2, 3, 5 and 6 are wrong because we want a cat. Cross out numbers 2, 3, 5 and 6. Now we have a big cat and a small cat. Which is correct? That's right - number 1, the big cat is the right answer. It's the same size as the other cat in the row. Now you have seen that a row may contain a number of tunes and that if we use our tricks the problems are very easy to solve. When many things change, such as color, size and picture or position, we know we must look at each change separately and cross out the wrong answers for each tune. Then after we read all the tunes in a row, we can circle the right answer."

Post-Test Instructions

The Post-Test should be given within three days and no more than a week following the first session by the same tester. The session again lasts either 30 minutes or until all but one or two subjects have finished. Before the subjects start working, the tester briefly summarizes the "tricks" they have learned in the previous session, encouraging the subjects to use them and expressing confidence in their improved ability. Do not test children who were absent in the first session.

Have all the children fill out the face sheet as they did in the pre-test session and open to the first page. "This book (indicate post-test booklet) is similar to the one you did before. Remember that you have to find the picture which belongs in the empty space and then put a circle around the choice you think is the right anser. This time, you should use all the tricks you learned the last time. Look for all the different things that change in the row: color, size, or picture. Then sing the tune for each change separately and cross out the wrong answers as you go along. Don't

forget the trick of starting at the other end when the empty space comes at the beginning of the row. Remember to circle only one answer and not to skip any rows.

Scoring

The score is the number of items answered correctly. Use the scoring key and do not trust your judgment. Give credit only when one choice (the correct one) was circled. Occasionally a child may circle a picture in the series instead of the provided choices. Give credit if the choice is correct and the only one circled.

Record the scores on the face sheets of the pre-test and post-test booklets. The format is as follows:

AP (apple) Pre-Test

Series	
pict.	items 1-40
geo.	items 41-50
total	items 1-50
Matrices	
pict.	items 51-55
geo.	items 56-65
total	items 51-65
Total	items 1-65

TB (teddy bear) Post-Test

	TB	AP
Series		
pict.	items 1-40	1-40
geo.	items 41-50	41-50
total	items 1-50	1-50
Ma rices		
pict.	items 51-55	51-55
geo.	items 56-65	56-65
Total	items 1-65	1-65

Scoring Key

ITEM	ANSWER	ITEM	ANSWER
1	3	34	3
2	2	35	1
3	1	36	2
4	4	37	4
5	2	38	6
6	3	39	1
7	3	40	5
8	1	41	3
9	4	42	1
10	1	43	4
11	2	44	2
12	4	45	3
13	2	46	1
14	2	47	5
15	4	48	6
16	3	49	2
17	4	50	4
18	1	51	3
19	1	52	4
20	2	53	2
21	3	54	2
22	3	55	6
23	1	56	3
24	4	57	4
25	4	58	3
26	2	59	1
27	4	60	4
28	3	61	2
29	2	62	2
30	1	63	1
31	6	64	6
32	5	65	2
33	1		